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DEVELOPMENT OF A REAL TIME RESUPPLY MODEL FOR FORWARD AREAS OF CARE

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Development of a Real Time Resupply Model for Forward Areas of Care

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Summary

Background

Currently, no medical supply modeling efforts have been directed toward the resupply of forward medical treatment facilities (MTFs). Resupply is critical for delivery of medical care in far forward environments, but the process presents many obstacles.

Objective

The objective of this work is to develop a computer model, known as MedRes, for predicting resupply items based on casualty treatment information and the use of supplies to treat those casualties. The Naval Health Research Center (NHRC) Estimating Supplies Program (ESP) provides the initial supply inventories, while the MEDTAB/MEDTRAK software system captures and stores casualty treatment. The resupply model uses this treatment information to determine the utilization of specific supplies and predict the drawdown of supply inventories.

Approach

A computer model for predicting resupply items was developed. First, the MedRes program extracts the required data elements from the patient's medical record. The supplies needed to render those medical treatments are then aggregated and the drawdown of supply inventories predicted. This resupply capability was developed by combining and enhancing previously developed systems.

Results

The MedRes model can be used to answer questions regarding the location and amount of supplies. Items in very short supply and items needed for critical life-saving tasks can be quickly identified. MedRes utilizes MEDTRAK to generate reports detailing numerous types of data, such as the percentage of available supplies for each functional area, and the availability of critical supplies. The supply database has the features of any database; that is, the contents can be searched, added, or deleted. The computer model also predicts the supply utilization rate, and then generates the appropriate reports for medical regulating, patient movement, patient evacuation, and medical resupply. The various functional areas in the Surgical Company can use MedRes to determine the location and track the use of supplies, as well as reorder supplies before they become critically low.

Discussion

MedRes uses the patient documentation capability of the MEDTAB/MEDTRAK system to identify treatment and utilization of medical supplies. MedRes incorporates anticipatory resupply to provide logistics planners the ability to forecast medical supply requirements.

Introduction

The mix of medical supplies and equipment deployed to treat Marine Corps combat casualties are determined by the compositions of the Authorized Medical Allowance Lists (AMALs) and Authorized Dental Allowance Lists (ADALs). Having the accurate amount, type, and configuration of medical supplies and equipment is essential for treating Marine casualties at forward medical treatment facilities (MTFs). As supplies are consumed, however, resupply for a forward MTF also becomes critical. The current resupply process can be cumbersome and unreliable. Problems with the resupply process experienced by forward MTFs include delays in receiving shipments, inability to resupply in small or individual quantities, overstocking of infrequently used items, and overcoming the complex supply request process (Magee, 1997). New communications technology and improved supply processes have alleviated some of these problems. However, a system that employs new technology to document patient admission and treatment data, generate and aggregate the supplies needed to treat those conditions, and use that information to anticipate resupply requirements is needed. The Commandant of the Marine Corps requested a system (HQ USMC ltr 1000, LPP-2) that uses patient admission and treatment data to anticipate resupply requirements, allowing for the ordering of individual items based on supply utilization.

The Modeling and Simulation Program Area at the Naval Health Research Center (NHRC) has done extensive work in developing medical documentation software. One software system developed specifically for use by the Marine Corps at forward MTFs is the MEDTAB/MEDTRAK system (Emens-Hesslink, Konoske, & Gauker, 1997). These two software programs work together to form a complete medical documentation and patient tracking system. MEDTAB documents patient medical information by allowing the user to enter essential injury and treatment data, orders for follow-on treatment, a range of patient conditions, and the final disposition of the patient. MEDTRAK acts as a computerized intrafacility patient tracking system that automatically tracks patient location as a casualty moves throughout the facility. Aggregating the patient treatment and tracking information may also be useful to medical planners and logisticians in determining priorities for evacuation, monitoring flow through the medical facility, gathering bed and blood status information, generating reports, and possibly monitoring the utilization and location of medical supplies.

Equally important to medical information documentation and patient tracking is ensuring that medical personnel have the correct amount and type of supplies and equipment for delivering medical care. NHRC has recently developed the Estimating Supplies Program (ESP) to accomplish this challenging task (Tropeano, 2000). By establishing mission-specific clinical requirements for the items pushed forward, significant reductions in medical materiel requirements for forward area supply blocks have been achieved (Konoske, Galarneau, Pang, Emens-Hesslink, Gauker, & Tropeano, 2000). This approach has reduced the logistical burden carried by the medical battalions without reducing the level or quality of care provided (Galarneau, Konoske, Emens-Hesslink, Pang, & Gauker, 1997).

NHRC's development of the MEDTAB/MEDTRAK software system and ESP can be expanded to encompass anticipatory resupply capability. Shahbaz and Zdyb (1998) stated that the use of

anticipatory and predictive logistics for medical resupply could be an improvement over demand-based supply practices. Anticipatory resupply requests are generated based on the number of casualties flowing through the unit and represent the effect of situational awareness on medical resupply. The amount of supplies ordered through this anticipatory model is dependent on the number and severity of casualties for the period being examined. With the introduction of anticipatory logic, Shahbaz and Zdyb found a slight increase in the total amount of supplies shipped when compared with demand-based medical logistics. They found, however, that a demand-based system generated more emergency requests, which required unforecasted transportation requirements and made the logistics planner's job more difficult. With the introduction of anticipatory logic, there can be a significant decrease in the number of emergency requests submitted. Although Shahbaz and Zdyb looked at transportation assets and not at specific medical supply items, they concluded that with anticipatory logistics there is a more predictable flow of supplies into the forward area, allowing logistics planners to better forecast requirements.

This paper describes the development of MedRes, an anticipatory model that determines resupply requirements. MedRes combines ESP and its supply databases with the MEDTAB's casualty treatment data and MEDTRAK's location and tracking capability to determine real time resupply requirements in theater.

Objective

The objective of this work was to develop a computerized resupply model called MedRes that uses a knowledge base composed of detailed treatment protocols describing the medical care sequence a casualty undergoes. This resupply capability was developed by combining and enhancing two previously developed systems. The first system, the MEDTAB/MEDTRAK software system captures, stores, and aggregates patient treatment and tracking information, while the second system, ESP, provides the initial supply inventories and their link to medical tasks. MedRes essentially links these two systems; by entering actual patient treatment information into MEDTAB/MEDTRAK, the supplies required to treat those patients are determined by using the Medical Supply Model. Operated in such a manner, this function would be transparent to the user and performed as another automated process of the MEDTRAK system.

MEDTAB: A Medical Documentation System for Medical Treatment Facilities

MEDTAB was developed to record detailed treatment, diagnosis, and disposition data typical of a Battalion Aid Station (BAS) or forward Surgical Company encounter. MEDTAB uses a casualty's Smart Card as a rapid method for admitting the patient into the facility, displaying patient history data, and tracking the patient's current location. Once treatment has been rendered at the medical facility, MEDTAB is used to record a complete description of the medical encounter. The device's interface allows the medical provider to enter additional injury and treatment data, lab and x-ray results, surgical procedures, orders for follow-on treatment, a range of patient conditions, and the final disposition of the patient. Upon discharge from the facility, all accumulated medical data are uploaded onto the casualty's Smart Card for transfer with the patient to the next level of care (Emens-Hesslink et al., 1997).

MEDTRAK: A Patient Tracking System for Medical Treatment Facilities

While in the MTF, MEDTRAK, a patient tracking program, automatically tracks patients via short-range radio frequency (RF) communication as they move through the facility. MEDTRAK consists of a network of hand-held, pen-based personal computers (PCs) equipped with RF capability to maintain communication with a central processing PC. MEDTRAK provides options for generating lists of the patients within the facility and the medical data collected on each of them from the time of initial injury. MEDTRAK has included the ability to set patient movement priorities, such as the patient queue for x-ray or the operating room, as well as the ability to generate facility reports in support of blood management, patient evacuation, medical regulating, logistics, command, and control. MEDTRAK was compared with the current manual method of patient tracking during mass casualty training exercises at the 1st Medical Battalion Surgical Company (Galarneau & Wilcox, 1994). Results showed that MEDTRAK admitted, identified, and tracked patients within the MTF significantly more accurately than did the manual system. In addition to improved patient accountability, the MEDTRAK system reduced the administrative burden patient tracking placed on medical personnel, thereby allowing them to perform clinical duties.

NHRC Estimating Supplies Program

Recent changes in Marine Corps doctrine and policy, as well as reduction in casualty rate estimates, have resulted in the need to revise the AMAL/ADAL configurations. The Marine Corps AMALs were reviewed to ensure that they reflect these recent changes. Briefly, the approach taken for this review was to identify the medical tasks required to treat patients with specific Joint Readiness Clinical Advisory Board patient condition codes, and to determine the supplies and equipment required for treatment. Subject matter experts reviewed treatment briefs, tasks, supplies, and equipment, and examined their usefulness to Marine Corps forward areas of care. The result of this effort is a database of the Marine Corps supply stream that establishes a clinical requirement for each item used to support forward medical care.

This approach is being used to configure the AMALs used by the Fleet Marine Force. When the BAS, laboratory, x-ray, operating room, triage, and ward AMALs were produced, results showed substantial reductions (approximately 30%) in the number of items required, weight, and cube of the proposed AMALs compared with the current Marine Corps AMALs (Konoske et al., 2000; Galarneau et al., 1997; Galarneau, Mahoney, Konoske, & Emens-Hesslink, 1997; Galarneau, Konoske, Emens-Hesslink, & Pang, 1998). By establishing clinical requirement for each item pushed forward, the NHRC model was able to reduce the logistical burden carried by Marine Corps units, yet enhance the clinical capability. This approach also produces an audit trail for each item because only items that can be clinically related to a treatment task conducted in theater are considered for inclusion in the AMALs. A computer program, ESP, was developed from this research to estimate supplies and equipment based on a given patient stream distribution.

The Marine Corps Combat Development Center has endorsed NHRC's review process and recommends that the process be used to evaluate the remaining AMALs. Additional efforts are underway to review supplies and equipment used by shipboard medical departments (Galarneau, Konoske, Pang, & Alvarez, 1999).

Methods

The patient treatment data gathered and aggregated using the MEDTAB/MEDTRAK system and the ESP databases were used in the development of MedRes. To ensure that as many medical tasks and supplies as possible could be documented and captured, the MEDTAB patient documentation capability was enhanced. Treatment tasks likely to be performed at the laboratory, x-ray, operating room, and ward areas of the Marine Corps Surgical Company were identified by subject matter experts from previous efforts and included in the upgrade. MEDTAB was modified to allow the care provider to order laboratory tests electronically and to access and view those test results by looking at the patient's medical record. This same capability was completed for x-ray. Also, procedures and forms for requesting laboratory tests and x-ray views and for reporting laboratory and x-ray results were added. Surgical procedures, anesthesia, and ward care tasks were added to MEDTAB so that patient treatment rendered in the operating room and ward functional areas could be fully documented.

MEDTRAK was improved to manage resupply information and to generate reports on MTF resupply requirements and supply inventory status. Subject matter experts, consisting of medical providers, medical planners, and patient movement personnel, from the 1st Medical Battalion, Camp Pendleton, participated in the identification of required system functions.

Next, the computer program for aggregating the medical treatment tasks recorded and stored by the MEDTAB/MEDTRAK system was designed. The treatment codes used by MEDTAB/MEDTRAK for documentation were mapped to those medical task codes used in ESP. This mapping was accomplished by converting the patient documentation software and the supply databases to common data file formats. Linking patient documentation to medical task is needed to successfully generate the supply requirements for each task.

Results

The MedRes model uses actual patient treatment information to identify the tasks required and the supplies associated with those tasks. These data are then used to determine the utilization of specific supplies and predict the drawdown of supply inventories. The resupply model uses data that are continuously collected using the MEDTAB/MEDTRAK system. These data elements are extracted from the casualty care medical records and assembled by MedRes. The supplies required to treat those medical tasks are aggregated, and the supply drawdown is determined.

Resupply Database Structure

A description of the resupply database structure, the tables, and the relationships between them is presented.

Task Table	This table contains a list of all the medical tasks. It provides a means of mapping MEDTAB's patient treatment information and medical tasks to medical tasks and required supplies in the NHRC Medical Supply Model databases.
Patient Condition Table	This table was built for the MARC ES computer program (Konoske, Dobbins, & Gauker, 1998) and contains the DEPMEDS list of 350 patient conditions.
Site Table	This table is built directly from the MEDTAB site list, creating one entry for each location in the MEDTAB MTF map.
Facility Table	This table lists those sites within the MTF where supplies are actually used. For each site, identifiers are assigned to the equipment and consumable AMALs.
Bill of Materials Table	This table lists the supplies needed for each task. It is a lookup table depending on the supplies required to perform a given medical task.
Transaction Log	This table tracks the transactions for the supply database. Patient treatment and medical tasks are recorded and compared against the supply database.
AMAL Table	The AMAL table lists the supplies issued for each treatment facility. It is built by appending the AMAL files to this table. These tables are used by MEDTRAK to determine what supplies are issued and to drawdown supplies for each completed medical task.
Supply Inventory Table	This table lists all the available supplies. It is created or updated to reflect the actual supplies issued to the MTF.
Supply Usage Table	This table lists the supplies used and the supplies still available for each location. The table is indexed in various ways to accommodate updates by functional area (laboratory, x-ray, operating room, ward), by supply item and by task. It is a working table used by MEDTRAK to update the supply database. The table can be accessed in several ways to create different reports.

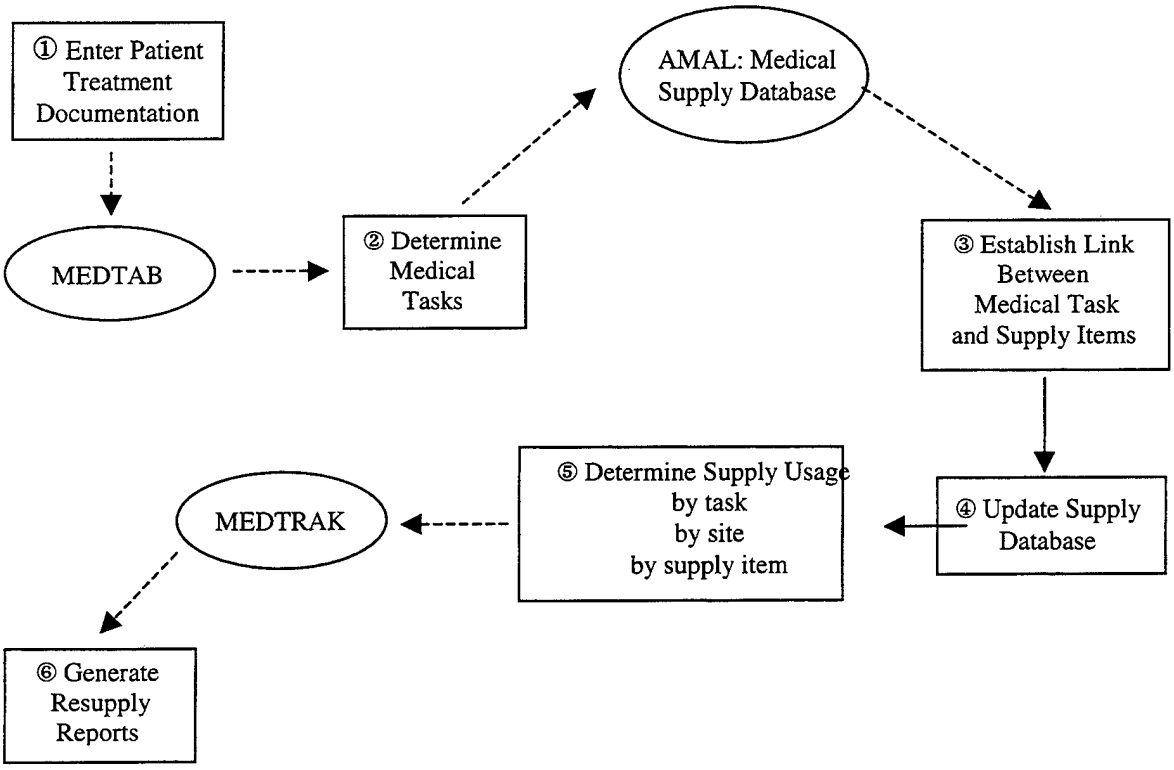
How MedRes Works

Figure 1 shows the flow of information in MedRes. The first step requires the medical provider to document the patient injuries, treatment, and condition using MEDTAB. The resupply program matches the patient treatment codes generated by MEDTAB with medical tasks listed in the NHRC Medical Supply Model database. The Medical Supply Model database links the medical tasks with the supplies required to perform those tasks. At this point, MedRes utilizes its two databases: the Supplies database and the Update database. The Supplies database contains total available supplies by location, supplies consumed at each location, and the original amount of supplies at each location. The original amount of supplies is calculated by adding the available supplies and the used supplies. The purpose of the Update database is to trigger an update in the Supply database. The Update database first analyzes the medical tasks by looking at each data element in the MEDTAB patient record to determine if there are any supply-related requirements. Scanning the patient's medical record indicates treatments, medications, and procedures that require supplies. MedRes looks up the supplies needed for each task, and for each supply determines the amount administered and the number of times the treatment is applied for the given treatment protocol. The amount used is then deducted from the Supply database.

Items in the Supply database can be searched for, added to, or deleted. MedRes can also calculate the percentage of available supplies for each functional area and the availability of critical supplies. The computer model estimates the supply utilization rate and then sends the information to MEDTRAK to generate the appropriate reports for patient tracking and medical resupply.

The resupply screen was designed to display supplies that have been used as well as the supplies that are remaining. Resupply can be calculated in real time or over a set period of time (e.g., once a day/hour) as defined by the user. Standard supply reports can be generated for any of the queries by supply name, functional area, patient condition, or task.

Figure 1. How MedRes Works



Database Queries and Report Generation

The main objective of MedRes is to capture supply utilization and therefore support resupply decisions. The database for this model also supports a variety of queries that may be of interest to medical planners. The queries and reports are accessed using the MEDTRAK program. The screens were formatted to be consistent with the other status reports already available.

The following is a list of the types of queries and reports that are available in MedRes.

Current Inventory

- Construct current inventory by item and original amount.
- Identify individual supply item quantities.
- Determine available and original amounts of supplies.
- Determine percentage of supplies remaining in a specific AMAL (MedRes uses available supplies and issued supplies [percentage = available/issued * 100]).
- Identify medical supply items that are dangerously low, items having only a certain percentage left (the user defines "low" and the report lists all supplies meeting that criteria).
-

Resupply/Readiness

- Generate resupply report.
- Identify National Stock Numbers or nomenclature by functional area to locate a needed supply.
- List items in more than one functional area by individual area or facility.
- List overstocked items.
- List most frequently used supplies and most frequently performed tasks.
- Identify supplies never used and the tasks associated with each.
- List supplies required by a particular task.
- Determine availability percentages of critical items needed to perform lifesaving tasks (such as maintaining airway, controlling bleeding, providing fluids, and administering medications [Bellamy, 1991; Butler, Hagmann, & Butler, 1996; Heydorn, 1990; Riley& Mahoney, 1996; Walsh, Lammert, & Devoll, 1989]).

In general, any table can be accessed. These can be used, for example, to generate reports or list the entities supported by the model. For maintenance of the supply database, items may be added, deleted, updated, searched, or reviewed. Queries can be constructed to indicate the amount of supplies in specific areas or the amount of supplies available to perform a particular medical task.

Discussion

Current Marine Corps doctrine states that supplies are pushed forward during a conflict, not requested. This doctrine avoids shortfalls due to communication problems and eliminates the burden on forward personnel to monitor supply inventories. The MedRes model provides a way to insure the right types and amounts of supplies are pushed forward and that the resupply is executed before existing materiel is exhausted.

It is important to note that resupply capability is designed to use information that is documented throughout the course of patient care; it is a passive process that requires no further activity than routinely provided patient care.

ESP databases were combined with the MEDTAB/MEDTRAK patient documentation and tracking system to identify treatment as well as the utilization and location of medical supplies. The MedRes model extracts the required data elements from the patient's medical record and

aggregates the supplies needed to render those medical treatments. The model predicts supply utilization rate and subsequently uses MEDTRAK to generate the appropriate reports for medical regulating, patient movement, patient evacuation, and medical resupply.

The databases of patient conditions, tasks, and supplies along with the MEDTAB/MEDTRAK system allow the user to query the software to discover essential information, such as which medical tasks are performed most frequently and in which facility location. Given this new capability, NHRC plans to identify other ways the databases can be used to perform more effectively and efficiently.

It is expected that improvements in capability will be realized using anticipatory resupply over demand-based resupply. This approach mitigates the risk of system failures that occur with demand-based systems. Incorporating the anticipatory resupply approach, MedRes allows for a predictable flow of supplies, enabling logistics planners to forecast requirements. However, the challenge remains to have medical logistics systems that support surges in workload at individual MTFs.

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14. ABSTRACT (maximum 200 words)

Currently, no medical supply modeling efforts have been directed toward the resupply of forward medical treatment facilities (MTFs). Resupply is critical for delivery of medical care in far forward environments, but the process presents many obstacles. The objective of this work was to develop a computer model, MedRes, for predicting resupply items based on casualty treatment information and the use of supplies to treat those casualties. This resupply capability was developed by combining and enhancing previously developed systems. The Naval Health Research Center (NHRC) Estimating Supplies Program (ESP) provides the initial supply inventories, while the MEDTAB/MEDTRAK software system captures and stores casualty treatment. The resupply model uses the patient treatment information to determine the utilization of specific supplies and predict the drawdown of supply inventories. First, the program extracts the required data elements from the patient's medical record. The supplies needed to render those medical treatments are then aggregated and the drawdown of supply inventories predicted. The MedRes model can be used not only to document patient diagnoses and treatment but can also be used to answer questions regarding the location and amount of supplies. Items in very short supply and items needed for critical life-saving tasks can be quickly identified. MedRes utilizes MEDTRAK to generate reports detailing numerous types of data, such as the percentage of available supplies for each functional area, and the availability of critical supplies. The supply database has the features of any database; that is, the contents can be searched, added, or deleted. The computer model also predicts the supply utilization rate, and then generates the appropriate reports for medical regulating, patient movement, patient evacuation, and medical resupply. The various functional areas in the Surgical Company can use MedRes to determine the location and track the use of supplies, as well as reorder supplies before they become critically low. MedRes uses the patient documentation capability of the MEDTAB/MEDTRAK system to identify treatment and utilization of medical supplies. MedRes accomplishes two functions with one data entry, medical providers can document patient care and provide logistics planners the ability to forecast medical supply requirements.

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